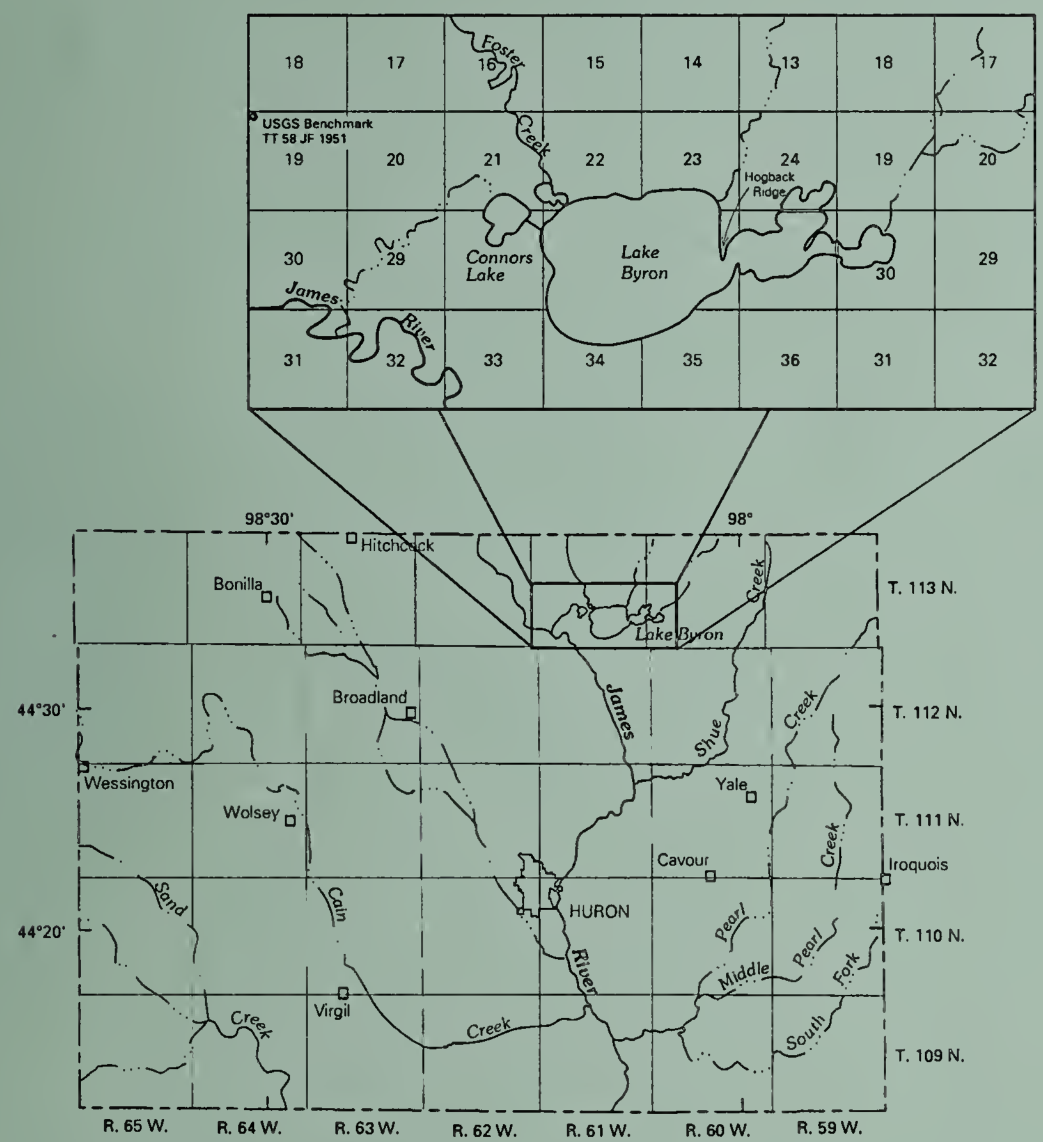
DETERMINATION OF SEDIMENT THICKNESS AND VOLUME IN LAKE BYRON, SOUTH DAKOTA, USING CONTINUOUS SEISMIC-REFLECTION METHODS, MAY 1992

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 93-4206



Prepared in cooperation with the

BEADLE CONSERVATION DISTRICT

U.S. GEOLOGICAL SURVEY
Huron Subdistrict Office
March 28, 1994

USE OF CONTINUOUS SEISMIC-REFLECTION METHODS TO ESTIMATE SEDIMENT THICKNESS IN SOUTH DAKOTA LAKES AND RESERVOIRS

INTRODUCTION

Sedimentation has several negative impacts on lakes and reservoirs in South Dakota. High sedimentation rates can reduce storage capacity and limit the effective life of lakes and reservoirs. Sedimentation has negative impacts on habitat of fish and other aquatic organisms, and also limits the recreational use of lakes and reservoirs. Additionally, organic-rich sediments can serve as a source of nutrients for algae and contribute to eutrophication, especially in shallow prairie lake systems.

Knowledge of the amount and distribution of sediment can be very useful in the management of lakes and reservoirs. This information memo describes a high-frequency seismic-reflection system used by the South Dakota District of the USGS to estimate thickness and volume of sediment in lakes and reservoirs.

METHODS

Continuous seismic-reflection systems transmit and receive high-energy acoustic signals through the water column and subsurface. When the signal encounters layers of different acoustical impedance (defined as the product of density of a medium and the velocity of the sound within the medium), part of the signal is reflected back to the surface seismic receiver and part penetrates further into the sediment. The strength of the reflection is dependent on the contrast in acoustic impedance between two adjoining layers. The average velocity of sound in pure water and saturated sediments is approximately 5,000 ft/s (Gorin and Haeni, 1988), and this velocity is used in calculating sediment depths. A tuned transducer generally operating at a frequency of 7 kilohertz is used. The transducer is extended from a boom and towed alongside a pontoon boat. The transducer is submersed about 1 foot below the water surface during operation. The reflection signal from the transducer is recorded on a thermal chart recorder on the boat. A digital audio tape recorder is also used to record the reflection signal and allows playback of the signal for fine tuning and interpretation during data analysis. To verify interpretation of the seismic record, manual coring techniques are used. Depending on the sediment composition, the coring procedures may allow typification of the sediment materials as deep as 10 to 15 feet. Water depth is continuously recorded using a standard strip-chart fathometer operated from the boat.

Certain limitations preclude the use of seismic-reflection equipment in some aquatic systems. Direct signal from the transducer to the receiver obscures recorder output corresponding to about the first 5 feet below the water surface and generally limits use of the equipment to bodies of water deeper than 5 feet. Also, gas bubbles

act as strong reflectors of the acoustic signal and so pockets of gas produced during microbial decomposition of organic matter and entrapped in sediments can interfere with penetration of the signal. Finally, very deep deposits of soft, loose, uncompacted sediment of gelatinous consistency can absorb the acoustic signal and limit penetration and reflection.

While operating the seismic--reflection system, the horizontal position of the pontoon boat is continuously monitored using a sub-meter-accuracy global positioning system (GPS). Accurate GPS positioning requires collection and post-processing of data that have been simultaneously transmitted by at least 4 NAVSTAR (NAVigation Satellite Time And Ranging) satellites and recorded by at least 2 receivers. One receiver is located at a USGS standard monument benchmark of known latitude, longitude, and elevation, and serves as a stationary reference base station. Another receiver serves as a continuously operated roving receiver attached to the deck of the pontoon boat. Data from the two receivers are post-processed using differential-correction techniques to give horizontal positions for the roving receiver that generally are accurate to 1 to 3 meters. The GPS horizontal positions are tied with the seismic record by periodically (approximately every minute) marking the thermal chart and recording an associated GPS clock time.

Data collected in the field, including water depth, sediment thickness, and horizontal position, are loaded into the ARC/INFO Geographical Information System (GIS) on the U.S. Geological Survey PR1ME computer in Huron, South Dakota, to produce contours of water depth and sediment thickness. The ARC/INFO GIS uses Delaunay triangulation to produce a triangulated irregular network of the data. Lines are then connected to points of equal value to produce contours (Environmental Systems Research Institute Inc., 1991). Volumes of water and sediment are calculated by multiplying the areas between contour lines calculated by the GIS times representative depths for each area.

EXAMPLE RESULTS

Figures 1-4 show seismic records and interpreted profiles for selected lake and reservoir sites in South Dakota. Figure 1 shows seismic record and interpreted profile collected in May 1992 from Lake Byron, a glacial kettle lake in Beadle County, South Dakota. The data were collected as part of a survey to determine the volume and distribution of lake sediments (Sando and Cates, 1993). Three distinct reflectors were consistently present in the seismic record: (1) a reflector at the top of the sediments; (2) a shallow reflector generally located 1 to 2 feet below the top of the sediments that was interpreted to be the interface between porous, organic-rich uncompacted sediment and compacted sediment; and (3) a deeper reflector generally located between 5 to 35 feet below the top of the sediments that was interpreted to be the interface between compacted sediment and glacial till comprising the original lake bottom. Manual coring was done to verify the seismic interpretation but penetration was restricted to the upper 3 feet of sediments. Coring results confirmed the interpretation of the shallow uncompacted sediment/compacted sediment interface, but penetration was inadequate to verify the interpretation of the deeper reflector. Four drill logs collected by the U.S. Bureau of Reclamation in the mid-1960's were

examined in an attempt to verify the deeper reflector. Although not located precisely at locations where seismic record was collected, the drill logs indicated the lake sediment and glacial till interface was 12 to 42 feet below the top of the sediments. These depths generally agreed with the range in the depth of the lake sediment/glacial till interface from the interpreted seismic record.

Figures 2 through 6 show seismic record and interpreted profiles from two reservoirs and one lake in South Dakota. The data were collected in October 1993 during a series of trials to test the operation of the seismic equipment on several locations in South Dakota. No coring was done to verify the interpretation of the seismic record for these trials, but manual probing was done with probes made of steel rod or 2-inch plastic PVC pipe to qualitatively assess the composition of the surficial (upper 0.5 to 3 feet) sediments.

Figures 2 and 3 show seismic record and interpreted profiles from Lake Madison, a glacial lake in Lake County, eastern South Dakota. Two reflectors generally were apparent in the seismic record: (1) the top of the sediments; and (2) a strong reflector that generally varied from 10 to 30 feet below the top of the sediments and was interpreted to be the lake sediment/glacial till interface. Manual probing indicated the surficial sediments generally were composed of coarse sand and gravel near the shore, and gradually changed to soft, silty sediment moving away from shore. This variation is apparent in the seismic record (fig. 2); near-shore areas had a darker, stronger reflection that gradually weakened and became lighter moving away from shore. As the reflection off the top of the sediments weakened moving away from shore, a greater part of the signal was able to penetrate into the sediments and then the reflector from the lake sediment/glacial till interface became more apparent. Substantial relief was apparent in the topography of the glacial till in some parts of the lake (fig. 3).

Figure 4 shows seismic record and interpreted profile from Lake Sharpe, a reservoir on the Missouri River, near Pierre. Manual probing showed variation in the surficial sediments which generally were composed of soft sand, fine-grained hard pan (probably shale), and gravel and cobble overlying hard pan. Pockets of deposited soft silty sediments as much as 2 feet deep were also present and were indicated as lighter weaker signals on the seismic record (fig. 4).

Figures 5 and 6 show seismic record and interpreted profiles from Lake Francis Case near the mouth of American Creek near Chamberlain. Manual probing indicated that the surficial sediments consisted of soft, fine-grained sediment except in near-shore areas. The seismic record indicated a fairly strong reflector 1 to 2 feet below the top of the sediments that was interpreted to be an interface between deposited sediment and an underlying subbottom probably composed of shale, or sand and gravel in the pre-inundation river channel. Just downstream from the mouth of American Creek, several remnant bridge piers exist in the reservoir where the pre-inundation river channel occurs. Seismic record collected near these piers indicated the reflector interface that generally occurred about 1 to 2 feet below the top of the sediments dropped several feet below the top of the sediments between the first

two piers. This pattern was interpreted to be two scour holes that had back-filled with deposited fine-grained sediment.

SUMMARY

A continuous seismic-reflection system has been effectively used by the USGS to detect interfaces between lacustrine deposits and underlying older deposits (such as shale, till, or alluvial materials) in a variety of lakes and reservoirs in South Dakota. The system is useful for determining depth, volume, and distribution of deposited sediment for lake and reservoir management.

REFERENCES

Environmental Systems Research Institute, Inc., 1991, Surface modeling with TIN-ARC/INFO user's guide: Environmental Systems Research Institute, Inc., Redlands, Calif.

Gorin, S.R., and Haeni, F.P., 1988, Use of surface-geophysical methods to assess riverbed scour at bridge piers: U.S. Geological Survey Water-Resources Investigations Report 88-4212, 33 p.

Sando, S.K., and Cates, S.W., 1994, Determination of sediment thickness and volume in Lake Byron, South Dakota, using continuous seismic-reflection methods, May 1992: U.S. Geological Survey Water-Resources Investigations Report 93-4206, 17 p.

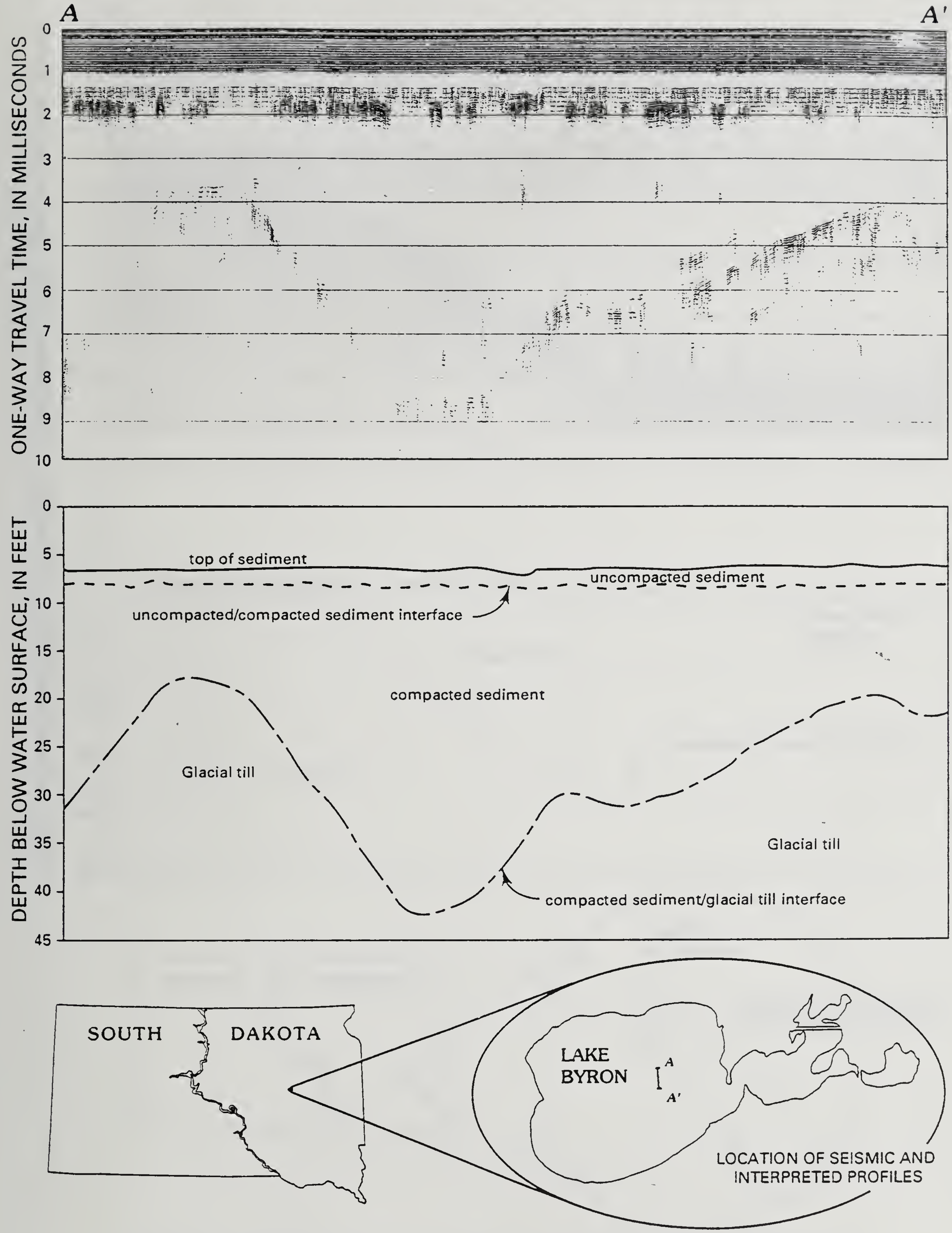


Figure 1.--Seismic record and corresponding interpreted profile from Lake Byron, South Dakota.

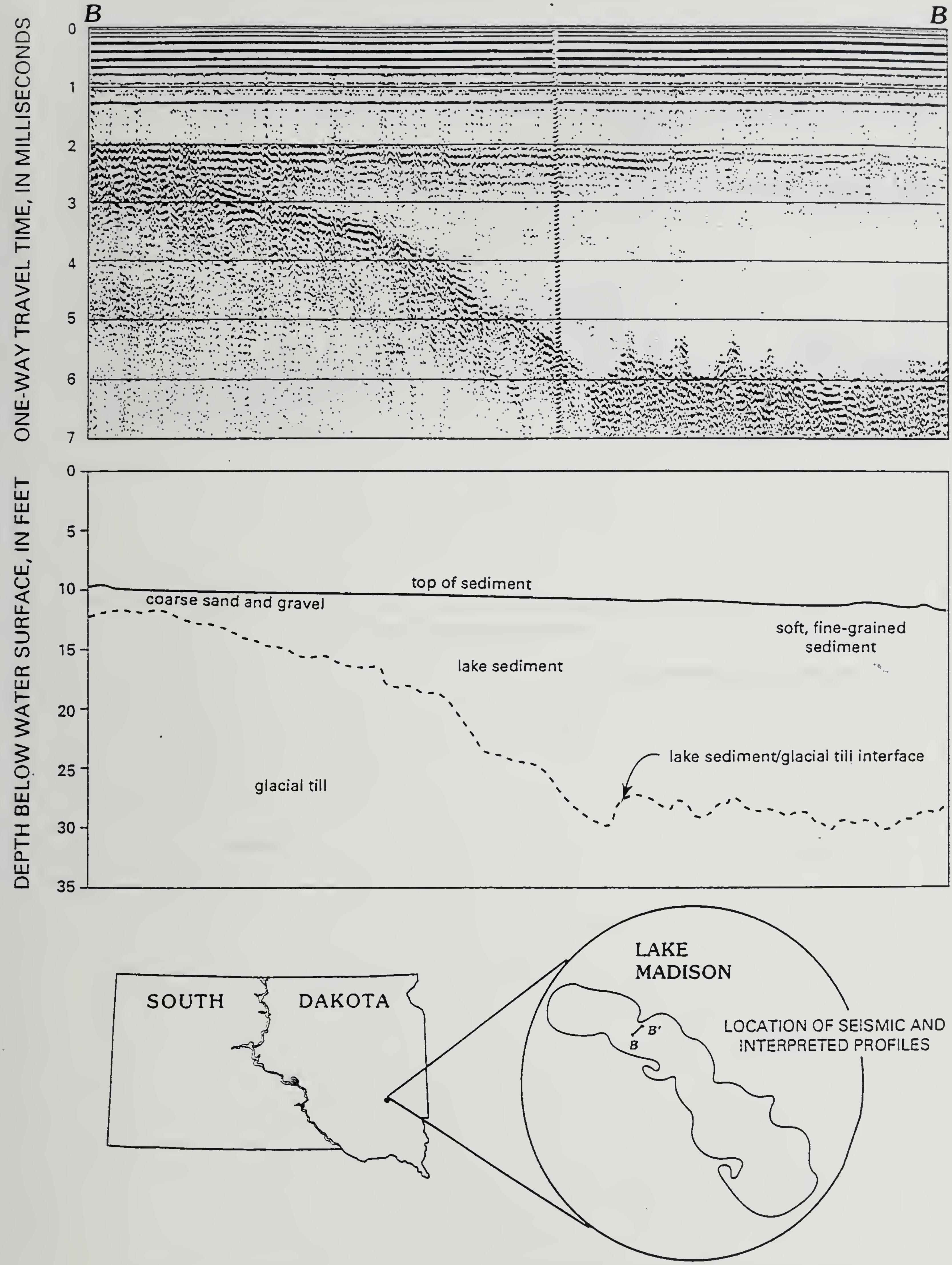


Figure 2.--Seismic record and corresponding interpreted profile from Lake Madison, South Dakota.

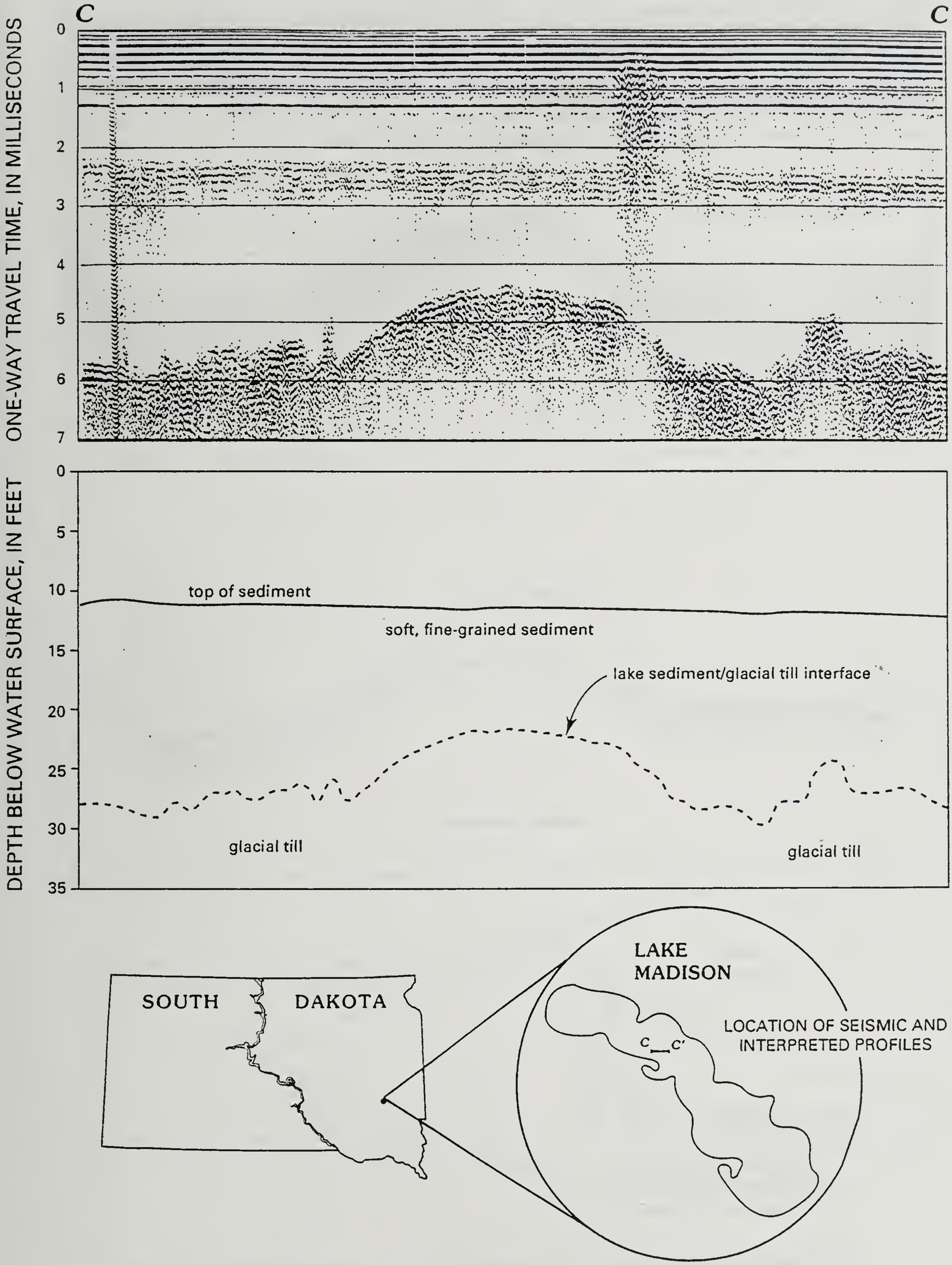


Figure 3.--Seismic record and corresponding interpreted profile from Lake Madison, South Dakota.

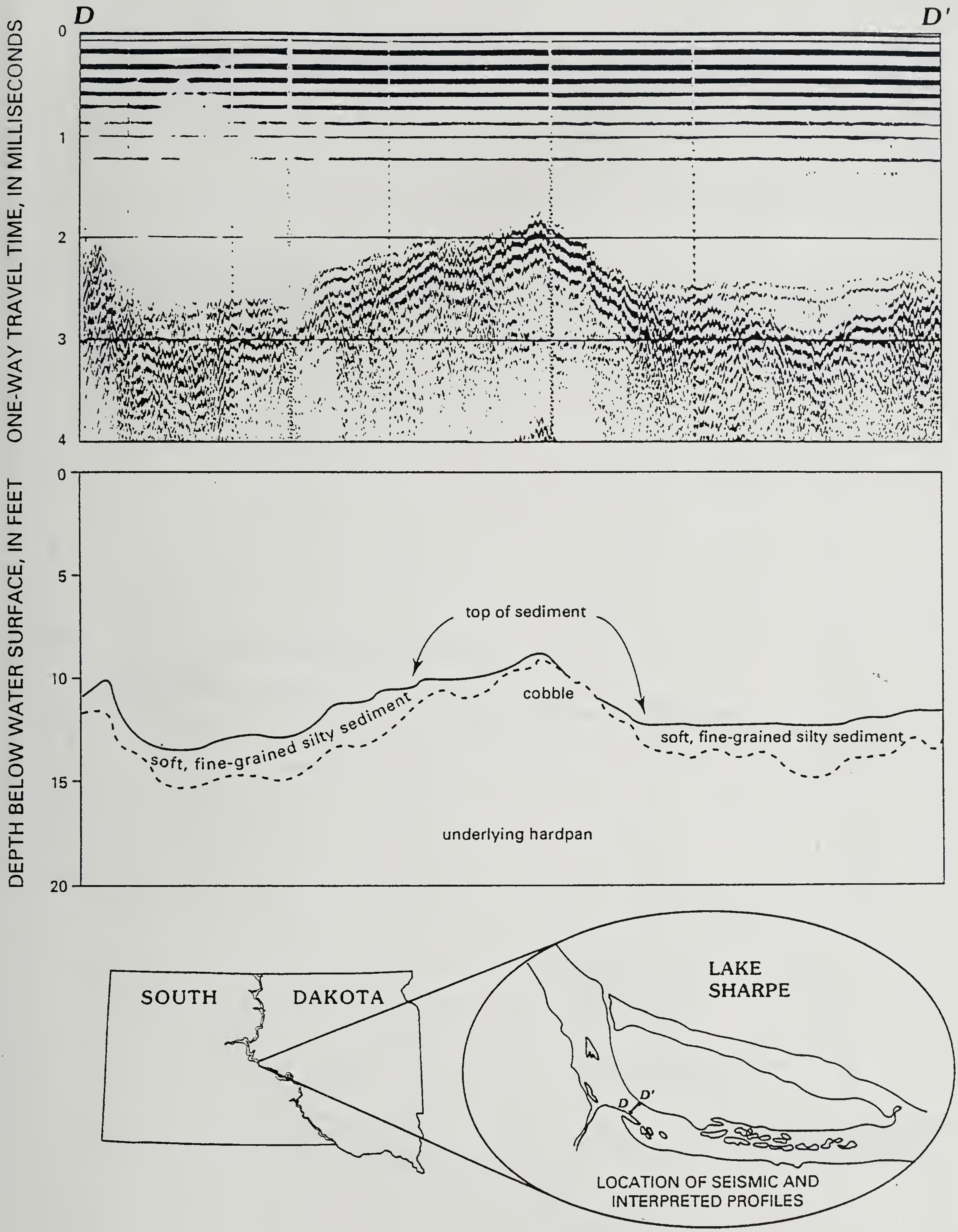


Figure 4.--Seismic record and corresponding interpreted profile from Lake Sharpe, South Dakota.

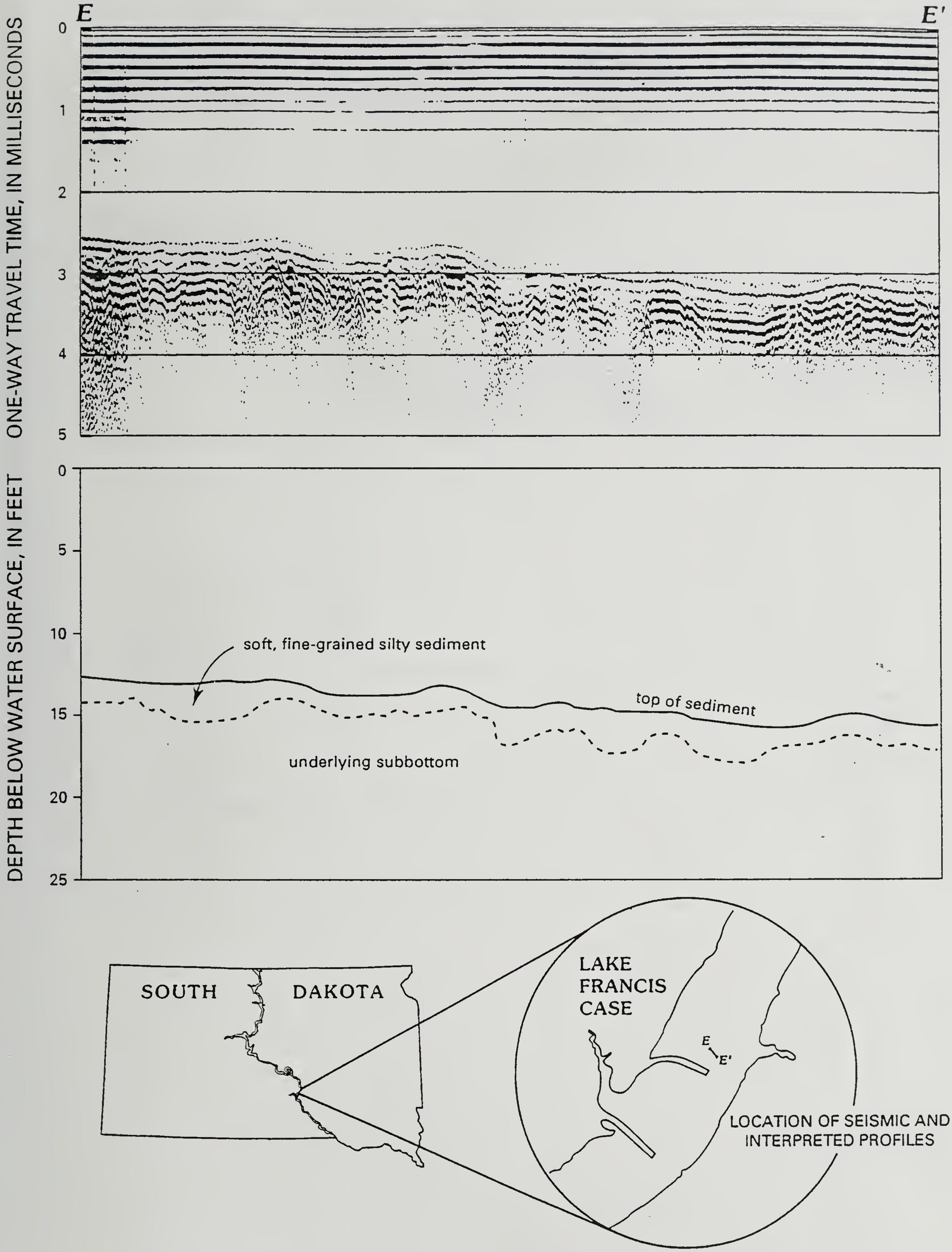


Figure 5.--Seismic record and corresponding interpreted profile from Lake Francis Case, South Dakota.

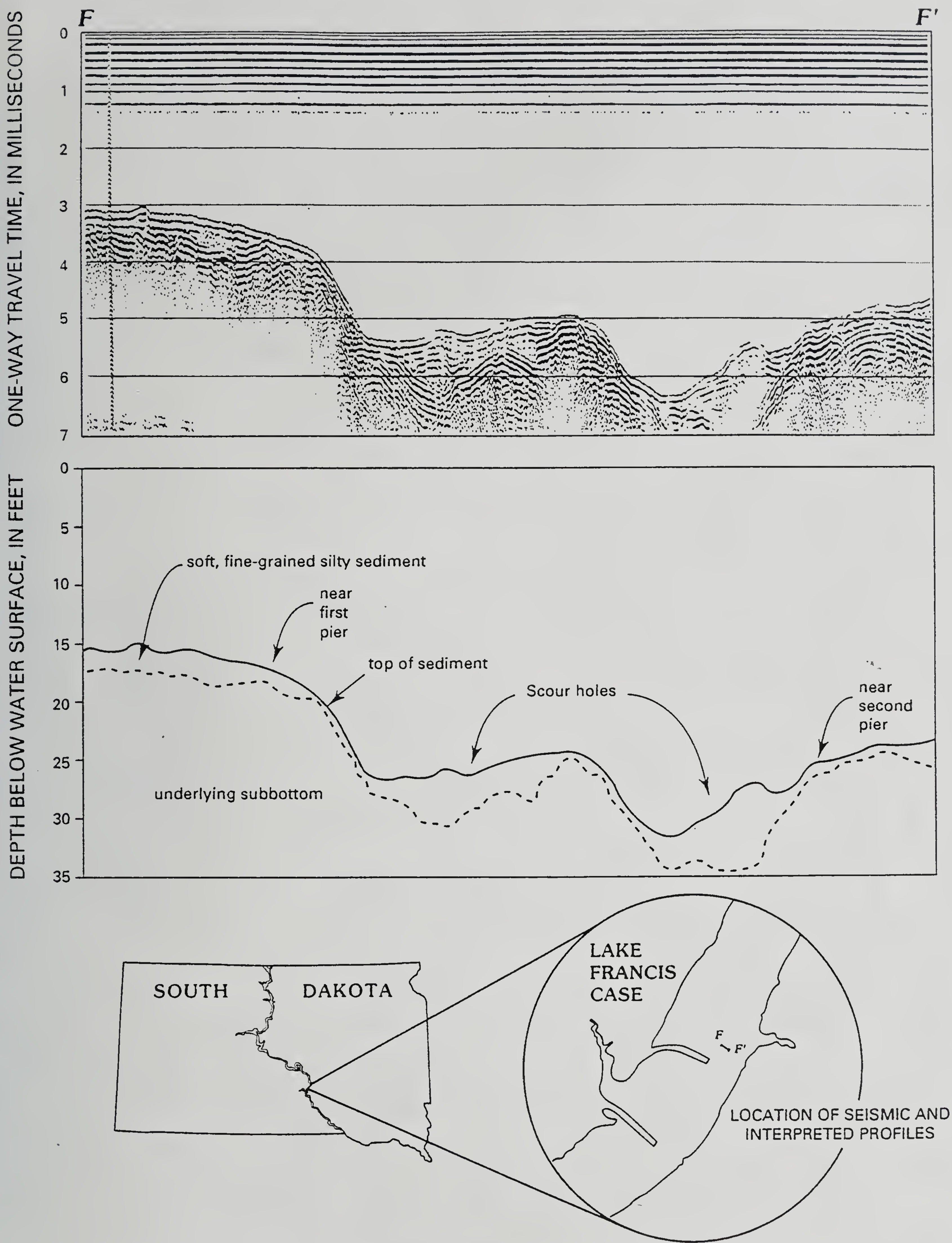


Figure 6.--Seismic record and corresponding interpreted profile from Lake Francis Case, South Dakota.

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[redacted]

By Steven K. Sando and Steven W. Cates

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 93-4206

Prepared in cooperation with the
BEADLE CONSERVATION DISTRICT

Rapid City, South Dakota
1994

CONTENTS

ILLUSTRATIONS

TABLE

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
acre	0.4047	hectare
acre-foot	1,233	cubic meter
cubic yard	0.7646	cubic meter
foot	0.3048	meter
foot per second	0.3048	meter per second
mile	1.609	kilometer
inch	25.4	millimeter
square mile	2.590	square kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929--a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ABSTRACT

A survey to assess the amount and distribution of lake sediment in Lake Byron, South Dakota, was made during May 1992 as part of a diagnostic/feasibility study investigating the potential for lake restoration. A high-frequency, continuous seismic-reflection system was used to estimate thickness of sediment, and a global-positioning system was used to monitor horizontal and vertical position while traversing 15 north-south and two diagonal transects of the lake. The water-surface elevation of Lake Byron during the sediment survey was 1,247.5 feet above sea level. The volume of water in Lake Byron was calculated as 10,645 acre-feet, and the average depth was 5.6 feet. The volume of loose, uncompacted sediment in Lake Byron was estimated to be 3.8 million cubic yards, and the average thickness of uncompacted sediment was estimated to be 1.2 feet. The volume of total lake sediment (uncompacted and compacted) in Lake Byron was estimated to be 34 million cubic yards. The average thickness of total lake sediment in the western part of Lake Byron was estimated to be 11 feet.

INTRODUCTION

Lake Byron is a natural lake in Beadle County, South Dakota (fig. 1), and is important as a recreational area, a waterfowl staging and nesting area, and as a secondary water source for the city of Huron. Lake Byron is eutrophic, and algal blooms often occur during summer months. Algal blooms and occasional large fecal coliform concentrations sometimes limit recreational use of the lake during summer months.

Lake Byron was listed as a priority water body by the South Dakota Nonpoint Source Task Force for improvement of water quality. As a result, a diagnostic/feasibility study was initiated in October 1990 to determine the trophic status of the lake and develop specific restoration alternatives (South Dakota Department of Environment and Natural Resources, written commun., 1990). Information about the amount and distribution of lake sediment was required as part of the diagnostic/feasibility study. Organic-rich sediments often serve as nutrient sources in shallow prairie lake systems (Keeney, 1973; Allan and others, 1980; Kenney, 1985), and restoration alternatives need to address the potential for removal of sediments.

The U.S. Geological Survey (USGS), in cooperation with the Beadle Conservation District, performed a sediment survey of Lake Byron during May 1992. The primary objective of the survey was to determine the thickness and volume of (1) loose, surficial, uncompacted lake

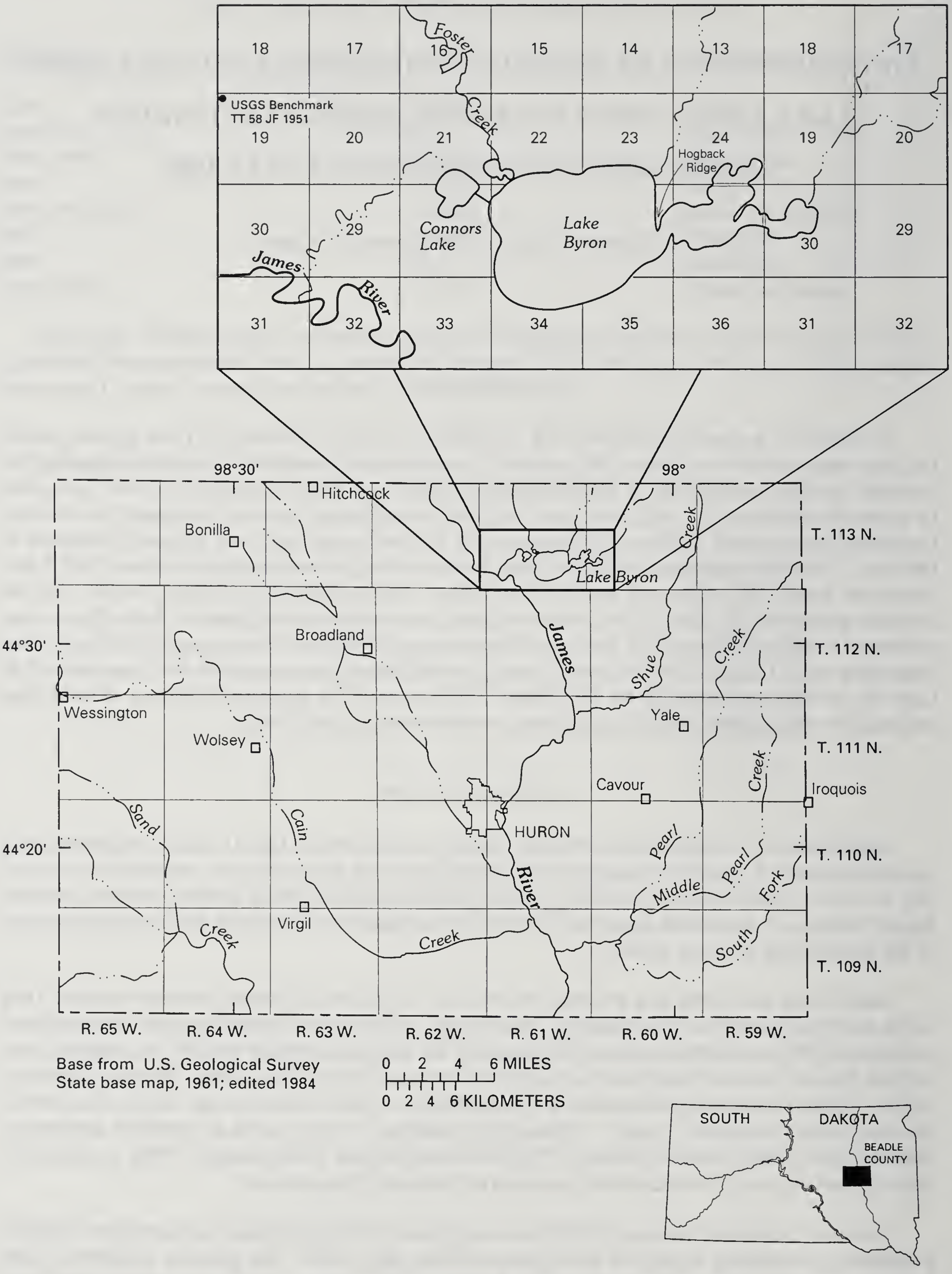

Figure 1.--Location of Lake Byron.

sediment; and (2) total lake sediment, consisting of the uncompacted sediment and deeper, compacted sediment (primarily clay and silt), deposited above the glacial till. Compaction of lake sediment may have occurred during dry periods when the lake bottom was exposed. All lake sediments that were surveyed were considered to be of post-glacial origin. A secondary objective of the study was to determine the depth and volume of water in Lake Byron. This report presents the results of the survey of Lake Byron.

Description Of Study Area

Lake Byron was formed as a kettle lake that developed in glacial drift that was deposited in an ancient drainage channel (Hedges, 1968). The glacial drift underlying Lake Byron consists primarily of glacial till of high clay content interspersed with layers of outwash. Ancient lacustrine deposits and Pierre Shale, Niobrara Formation, and Carlile Shale bedrock lie below the glacial drift.

Lake Byron has a drainage area of 238 square miles, and it is located in the James River basin in eastern South Dakota. About 25 percent of the area in the James River basin is noncontributing (U.S. Geological Survey, 1975), and this percentage probably also applies to the Lake Byron basin. Three principal tributaries that contribute surface water to Lake Byron are Foster Creek, and two unnamed tributaries that enter the northeastern part of the lake. During wet periods, the lake spills (at an elevation of about 1,249 feet above sea level) into a channel connected to Connors Lake, then back into Foster Creek, and subsequently the James River. The Lake Byron tributaries are ephemeral, drain lands that are primarily agricultural and mostly classified as highly erodible, and often have large concentrations of suspended sediment and nutrients (Beadle Conservation District, 1992). The hydraulic connection between Lake Byron and underlying aquifers generally is thought to be poor (Lewis Howells, U.S. Geological Survey, oral commun., 1992); discharge of ground water into Lake Byron or recharge of Lake Byron water to ground water probably is minimal.

Mean annual precipitation (1951-80) at Huron, located about 14 miles south of Lake Byron (fig. 1), is 18.7 inches (U.S. Department of Commerce, 1990). Mean annual free-water-surface evaporation for the Lake Byron area is about 43 inches (Farnsworth and others, 1982). Although documented records of stage for Lake Byron are sparse, infrequent reports of lake depth have indicated that water-level fluctuations are large presumably due to extremely variable surface-water runoff, very small ground-water contribution, and evaporation generally in excess of precipitation. The lake was reported to be dry during an extended dry period in the 1930's (Howells and Stephens, 1968). The difference in stage between the spill elevation and the lowest part of the lake is about 10 feet. In unusually dry years, the net annual stage decrease for Lake Byron may be as much as 3 feet, while in unusually wet years, the net annual stage increase may be as much as 1 foot (Roger Strom, South Dakota Department of Game, Fish and Parks, Huron, South Dakota, written commun., 1992).

Method of Study

A high-frequency, continuous seismic-reflection system was used to estimate thickness of sediment in Lake Byron. Continuous seismic-reflection systems transmit and receive acoustic signals through the water column and subsurface. When the signal encounters layers of different acoustical impedance (defined as the product of density of a medium and the velocity

of the sound within the medium), part of the signal is reflected back to the surface and part penetrates further into the sediment. The strength of the reflection is dependent on the contrast in acoustic impedance between two adjoining layers. The average velocity of sound in pure water and saturated unconsolidated sediments is approximately 5,000 feet per second (Gorin and Haeni, 1988). This velocity was used to calculate both uncompacted and total lake (uncompacted and compacted) sediment thicknesses for Lake Byron.

A tuned transducer system operating at a frequency of 7 kilohertz was used in this study. The transducer was extended from a boom and towed alongside a pontoon boat. The transducer was submerged about 1.5 feet below the water surface during operation. The signals from the transducer were recorded on a graphic recorder on the pontoon boat. A digital audio tape recorder also was used to record the subsurface reflections; however, all sediment-thickness estimates were made from the original graphic recorder record produced in the field.

To verify interpretation of the seismic record, 13 sediment cores were collected from Lake Byron while operating the continuous seismic-reflection system. Two-inch aluminum or PVC tubes with plastic core catchers epoxied into the ends were used to collect cores. The tubes were manually pushed into the sediments as far as possible, and then retrieved. Cores were analyzed by cutting open the coring tubes with an electric circular saw and visually examining the contents for obvious differences in composition and density of sediment materials.

Water depth was measured using a standard fathometer operated from the pontoon boat. Water depth was recorded continuously on a strip-chart recorder.

Fifteen generally north-south and two diagonal transects (fig. 2) to be traversed while operating the continuous seismic-reflection system and the fathometer were planned. Parts of the lake were too shallow to operate the seismic system because the outgoing signal interfered with the incoming reflection in water less than about 5 feet deep. In the shallow areas of the lake, sediment depths were estimated by frequently probing with a 1/2-inch solid steel rod and estimating the depth of penetration. Two bays of Lake Byron are isolated by road grades and it was not possible to get the pontoon boat onto these bays; therefore, no seismic or water depth record was collected.

While traversing the transects, the horizontal and vertical positions of the pontoon boat were monitored continuously using a high-accuracy three-dimensional global-positioning system (GPS). Accurate GPS positioning requires collection and post processing of data that have been transmitted simultaneously by at least four NAVSTAR (NAVigation Satellite Time And Ranging) satellites and recorded by at least two receivers. The seismic survey generally was conducted between the hours of 11:00 p.m. and 8:00 a.m., because this was the only time that a sufficient number of properly located satellites was available.

The Lake Byron GPS positioning was accomplished by using a combination of kinematic and static-positioning techniques. Static positioning was used to establish a stationary reference base station at a USGS standard tablet monument (USGS benchmark TT 58 JF 1951; fig. 1) of known latitude, longitude, and elevation located about 3 miles northwest of Lake Byron. Once the location of this reference base station was established, a network of reference stations could be positioned relative to the reference base station using differential static techniques (Leick, 1990). These reference stations were located at the end points of the north-south transects and were reoccupied during the seismic survey to provide periodic positioning checks. While conducting the seismic survey, a continuously operated roving receiver attached to the deck of

the pontoon boat provided kinematic positioning relative to simultaneously operated static positioning at the reference base station. Clock times taken from the roving GPS receiver were written on the seismic record (at about 1- to 2-minute time intervals) so the position data could be related to the seismic data.

Water depth, uncompacted and total lake sediment thicknesses, and horizontal position data were loaded into the ARC/INFO[1] Geographical Information System (GIS) on the U.S. Geological Survey Prime computer in Huron to produce contours of water depth and uncompacted and total lake-sediment thicknesses. The ARC/INFO GIS uses Delaunay triangulation to produce a triangulated irregular network of the data. Lines are then connected to points of equal value to produce contours (Environmental Systems Research Institute Inc., 1991).

For water depth and uncompacted sediment thickness, contours in the areas of the lake not accessible by pontoon boat were estimated by assuming that contour patterns were similar to nearby parts of the lake where data were collected. This assumption is probably reasonable because variability in the patterns of contour lines for water depth and sediment thickness generally was small; the contour lines were approximately parallel to the shore and there were few irregularities. The contour lines in the inaccessible areas were approximated by assuming that the lines were about parallel to the lake shore and the spacing between the contour lines was similar to relatively shallow, nearby parts of the lake where data were collected and where the water depth and uncompacted sediment thickness increased gradually from the shore toward the middle of the lake.

No total lake sediment-thickness contour lines were produced for the part of Lake Byron east of the constriction at the Hogback Ridge (fig. 1) due to lack of data. Total lake sediment-thickness contour lines were not approximated for the area east of the Hogback Ridge because there was relatively large variability and more irregularities in the pattern of total lake sediment-thickness contour lines.

Volumes of water and uncompacted and total lake sediment were calculated by multiplying the areas between contour lines by representative depths or thicknesses for each area. To estimate the total lake sediment volume in Lake Byron, it was assumed that the average thickness of total lake sediment calculated for the western part of the lake also was representative for the part of the lake east of the constriction at the Hogback Ridge.

SEDIMENT THICKNESS AND VOLUME

Water depth and spatial position were recorded at 494 locations along the transects for the sediment survey; 439 locations where seismic instrumentation was used, and 55 locations where manual probing was used. The actual paths followed while traversing the transects are shown in figure 3. Deviation from planned transects (fig. 2) were due to occasional motor failure and difficulty in navigating precisely to a destination located as much as 1.5 miles away. Differences between the planned transect paths and actual transect paths show the importance of accurate horizontal positioning during seismic surveys.

[1]Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

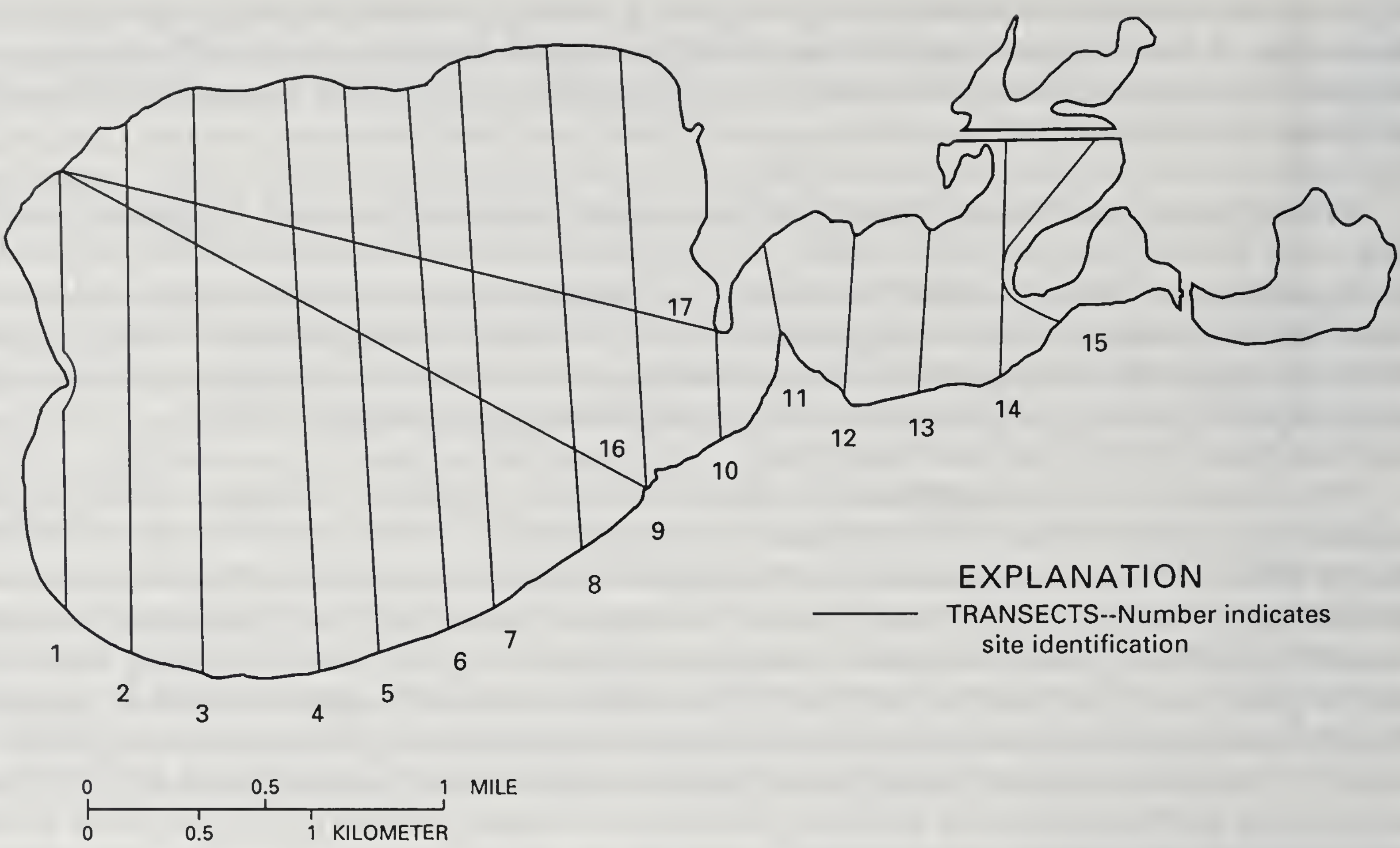

Figure 2.--Planned locations of transects for sediment survey of Lake Byron.

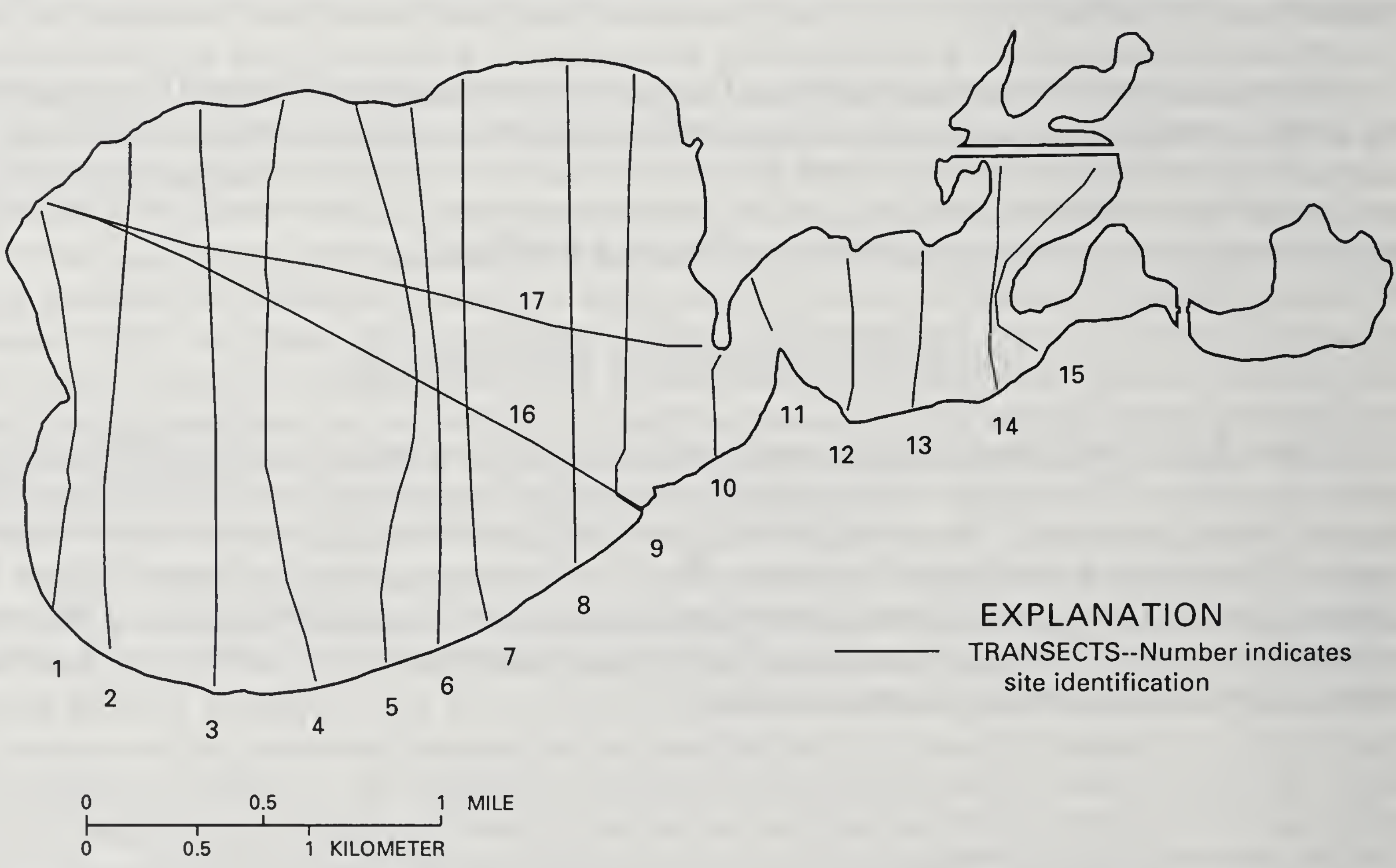

Figure 3.--Actual locations of transects for sediment survey of Lake Byron.

The water-surface elevation of Lake Byron during the seismic survey (May 12-15, 1992) was 1,247.5 feet above sea level. The volume of water in Lake Byron was 10,645 acre-feet, the surface area was 1,907 acres, and the average depth was 5.6 feet. Water-depth contours for Lake Byron are presented in figure 4. The water-depth contours tended to converge at transect end points and diverge between transects. This pattern probably is an anomaly of the ARC/INFO contouring software used in this study, and although it may have caused a slight underestimate in water volume for Lake Byron, the error is probably small. Elevation/capacity/area data for Lake Byron are presented in table 1.

***Table 1**.--Elevation/capacity/area data for Lake Byron, South Dakota*

[Data were collected during May 12-15, 1992]

Elevation (feet above sea level)	Capacity (acre-feet)	Area (acres)
1,247.5	10,645	1,907
1,247	10,624	1,826
1,246	10,475	1,653
1,245	10,182	1,524
1,244	9,865	1,437
1,243	9,461	1,325
1,242	8,848	1,191
1,241	7,407	992

Three reflectors consistently present in the seismic record (fig. 5) were: (1) a reflector at the top of the sediments; (2) a shallow reflector generally located 1 to 2 feet below the top of the sediments that was interpreted to be the interface between loose, uncompacted sediment and compacted sediment; and (3) a deeper reflector generally located between 5 to 35 feet below the top of the sediments that was interpreted to be the interface between compacted sediment and glacial till comprising the original lake bottom. Results of coring (fig. 6) generally indicate good correspondence between the interpreted uncompacted/compacted sediment interface from the seismic survey and a soft clay layer that consistently was present in the cores. With the coring methodology used in this study, it was not possible to penetrate the sediment far enough to verify the interpretation of the compacted sediment/glacial till interface. Drill-log data collected by the U.S. Bureau of Reclamation (USBR; Glenn Toucher, U.S. Bureau of Reclamation, written commun., 1992) during the winter of 1966 provide indirect evidence that the deeper seismic signal probably properly denotes the compacted sediment/glacial till interface (fig. 7). The USBR drill holes were located in the eastern part of Lake Byron where the water depth was too shallow to successfully operate the seismic instrumentation. Depth to glacial till in the four USBR drill logs ranged from 12 to 42 feet, generally similar to ranges in interpreted depth-to-till values taken from seismic record collected in other parts of Lake Byron.

The seismic record was not adequate to allow estimation of the uncompacted/compacted sediment and compacted sediment/glacial till interfaces everywhere. The continuous seismic record was evaluated and interpreted at 439 of the 494 locations for which water depth and spatial position were recorded. The shallow reflector was clear enough in 358 out of 439 seismic record/spatial position locations to allow delineation of the uncompacted/compacted sediment

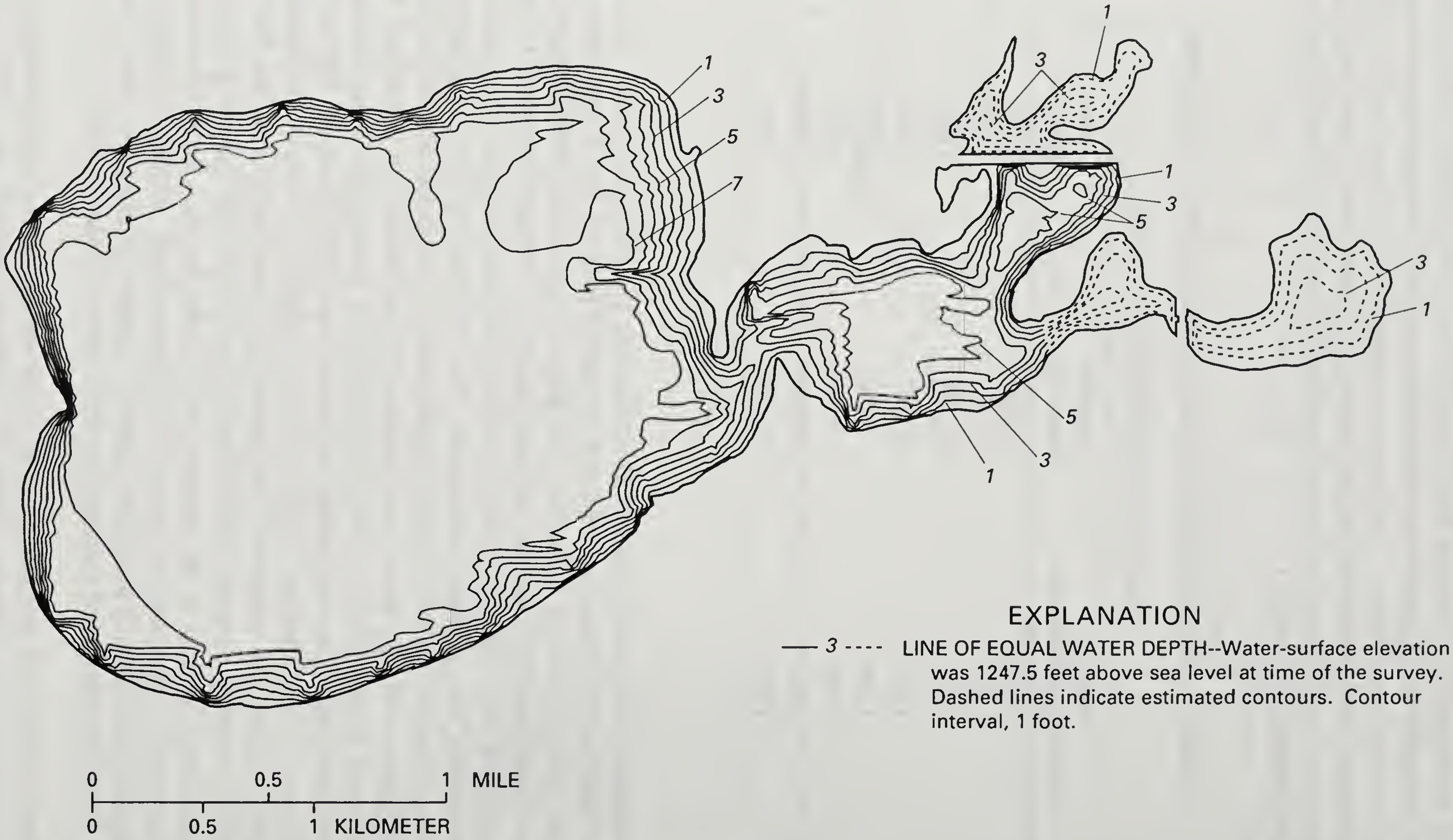

Figure 4.--Water-depth contours for Lake Byron (data collected during May 12-15, 1992).

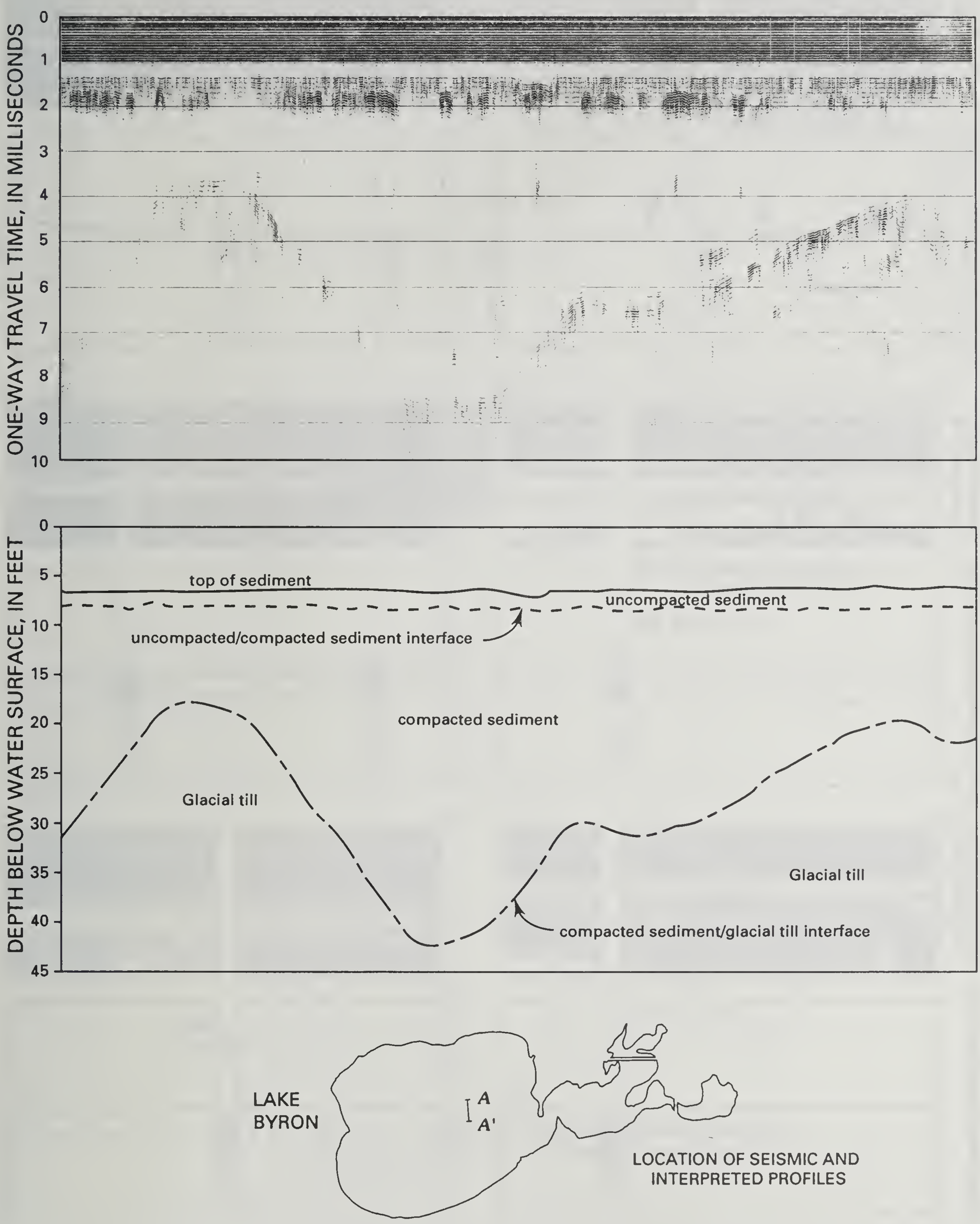

Figure 5.--Example of continuous seismic-reflection record and interpreted profile showing different reflectors.

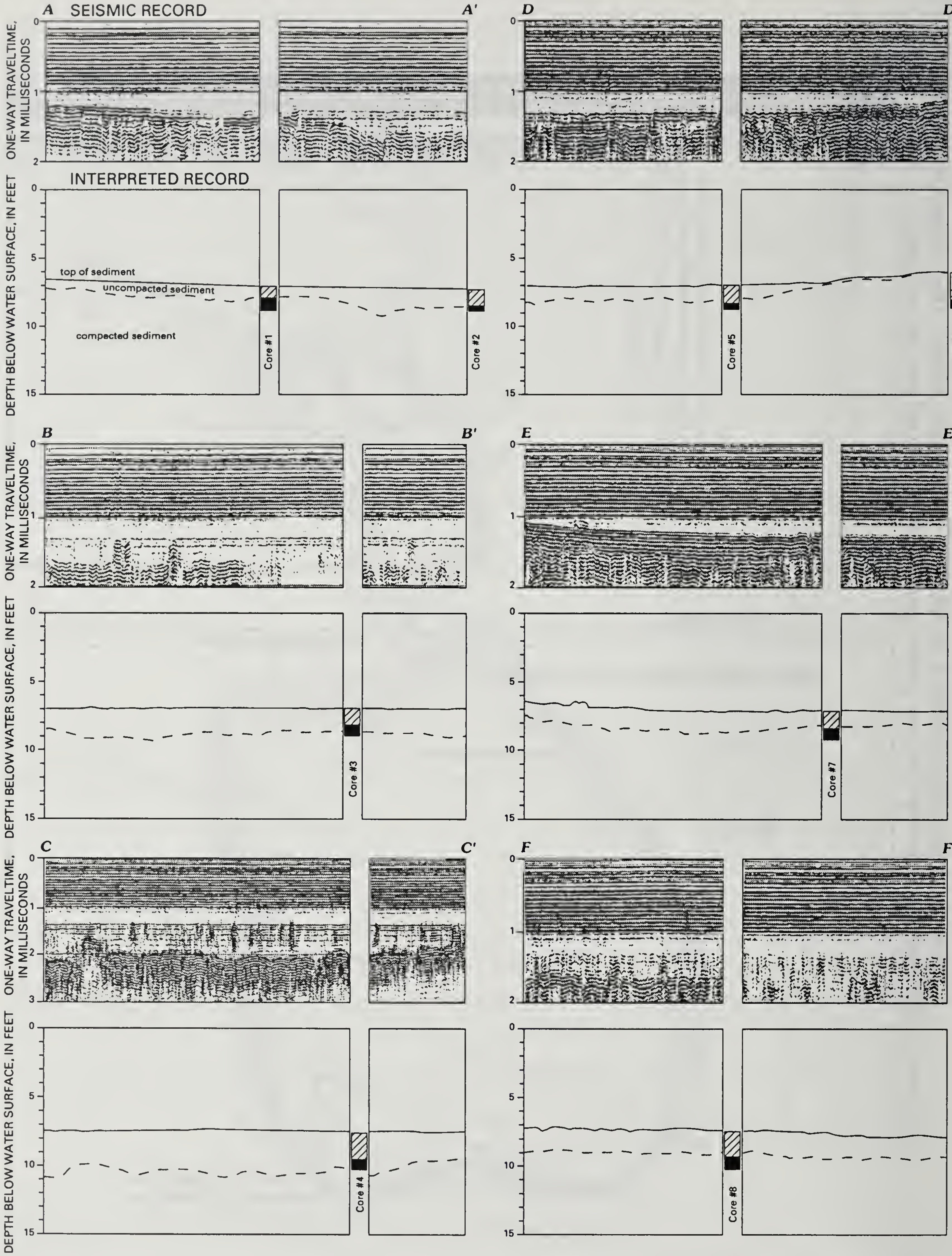

Figure 6.--Continuous seismic-reflection record, interpreted profiles, and core descriptions for Lake Byron.

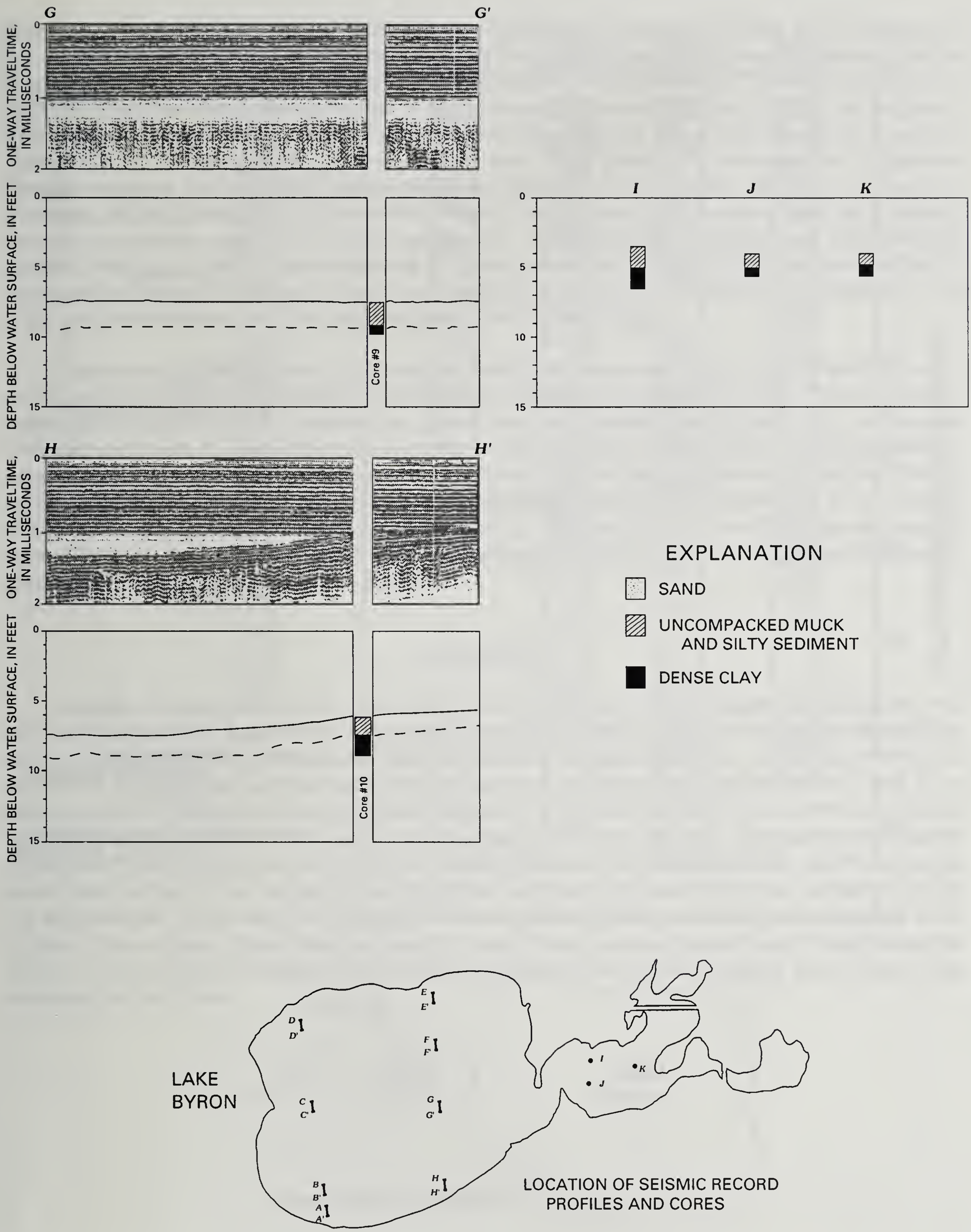

Figure 6.--Continuous seismic-reflection record, interpreted profiles, and core descriptions for Lake Byron.--Continued

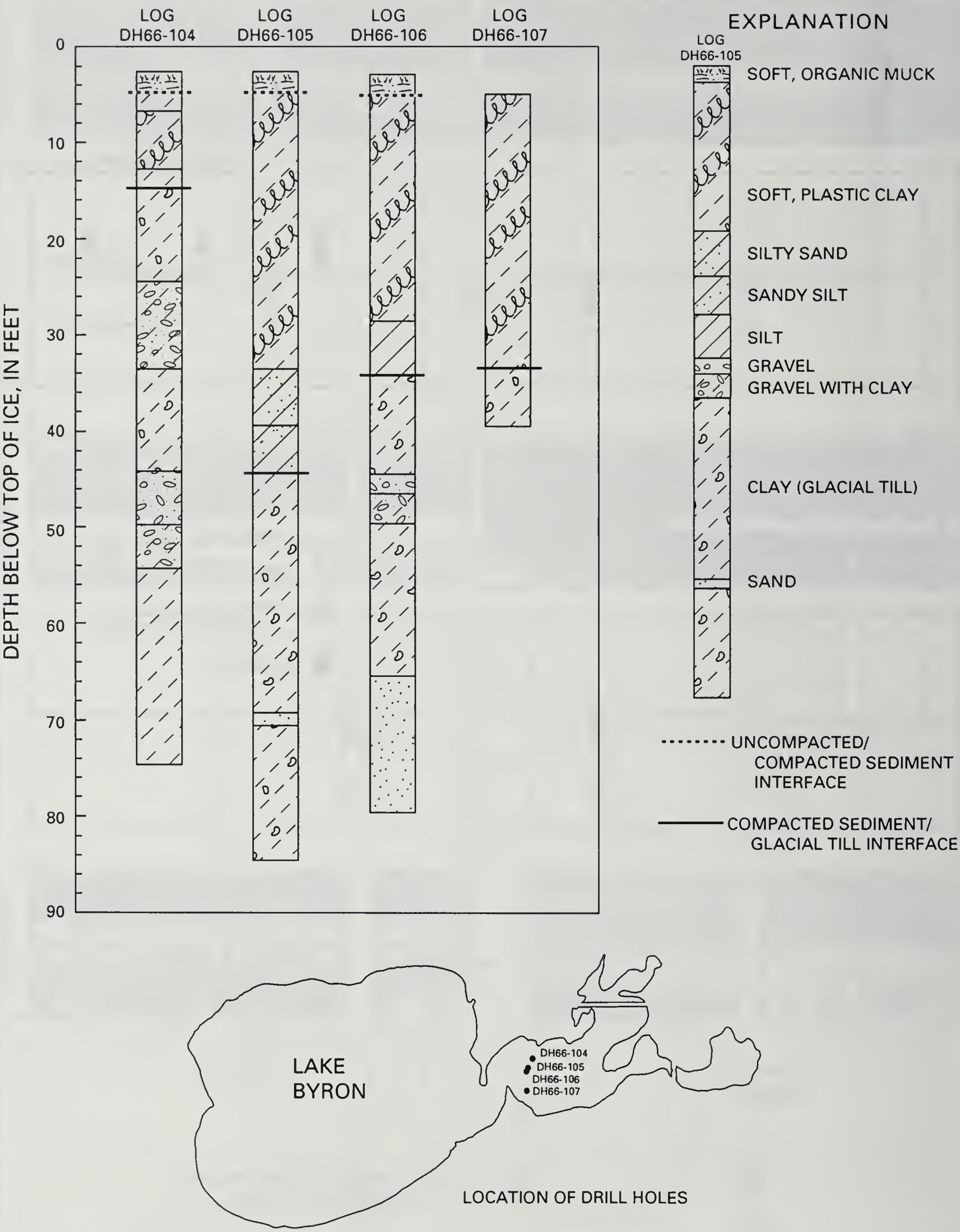

Figure 7.--Drill-log profiles for four U.S. Bureau of Reclamation drill logs collected in 1966 (from Glenn Toucher, U.S. Bureau of Relamation, Billings, Montana, written commun., 1992).

interface. Depth of uncompacted sediment was estimated by manual probing at 55 locations in the part of the lake east of the constriction at the Hogback Ridge (fig. 1) where the water depth was too shallow for successful operation of the seismic instrumentation. Therefore, depth of uncompacted sediments was estimated at 413 locations, 84 percent of the locations having data. The seismic record of the deeper reflector was adequate in 126 of the locations to allow delineation of the lake sediment/glacial till interface. This constitutes a coverage of 26 percent. Smaller coverage for the deeper compacted sediment/glacial till interface was due to occasional presence of multiple signals in the seismic record that obscured the deeper signal, and absorption of the seismic signal by the lake sediments. Although the coverage was substantially smaller, the data probably were adequate to provide reasonable control for contouring of thickness and estimates of volume of both uncompacted and total lake sediment, especially in the main part of the lake west of the constriction at the Hogback Ridge.

The volume of uncompacted sediment in Lake Byron was estimated to be 3.8 million cubic yards, and the average thickness of uncompacted sediment was estimated to be 1.2 feet. Uncompacted sediment-thickness contours for Lake Byron are presented in figure 8. The volume of total lake sediment in Lake Byron was estimated to be 34 million cubic yards. The average thickness of total lake sediment in the part of Lake Byron west of the constriction at Hogback Ridge was estimated to be 11 feet. Total lake sediment-thickness contours for Lake Byron are presented in figure 9. Interpreted cross-sectional profiles for selected transects with adequate seismic record for both the uncompacted/compacted sediment interface and the compacted sediment/glacial till interface are presented in figure 10.

SUMMARY

A sediment survey to assess the amount and distribution of uncompacted sediment and total lake sediment in Lake Byron was made during May 1992 as part of a diagnostic/feasibility study investigating the potential for lake restoration. A high-frequency, continuous seismic-reflection system was used to estimate thickness of uncompacted sediment and total lake sediment, and a global-positioning system was used to monitor horizontal and vertical position while traversing 15 north-south and two diagonal transects of the lake. The elevation of Lake Byron was 1,247.5 feet above sea level, the volume of water was 10,645 acre-feet, and the average depth was 5.6 feet. The volume of uncompacted sediment in Lake Byron was estimated to be 3.8 million cubic yards, and the average thickness of uncompacted sediment was estimated to be 1.2 feet. The volume of total lake sediment in Lake Byron was estimated to be 34 million cubic yards. The average thickness of total lake sediment in the western part of Lake Byron was estimated to be 11 feet.

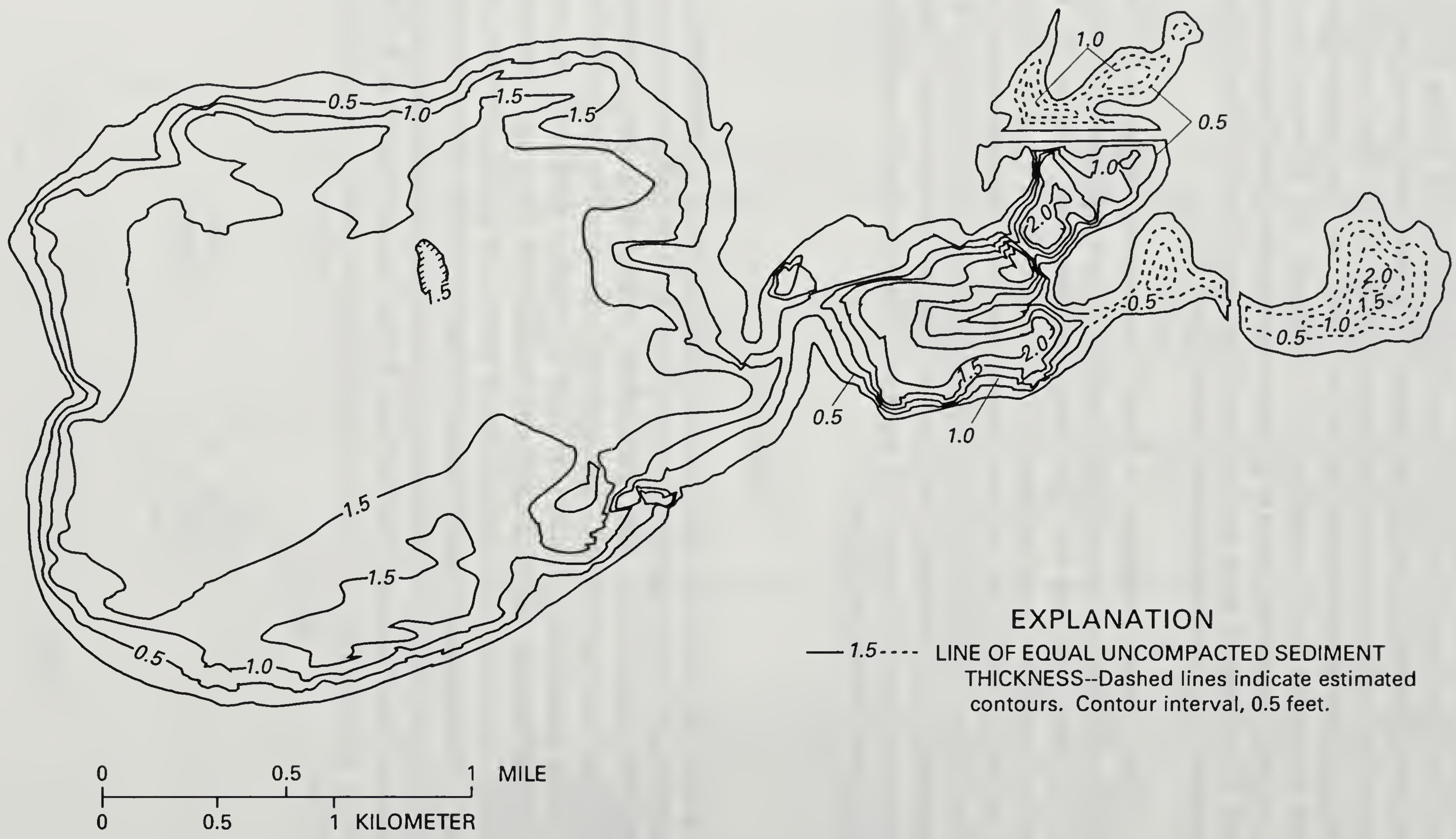

Figure 8.--Loose, uncompacted sediment-thickness contours for Lake Byron.

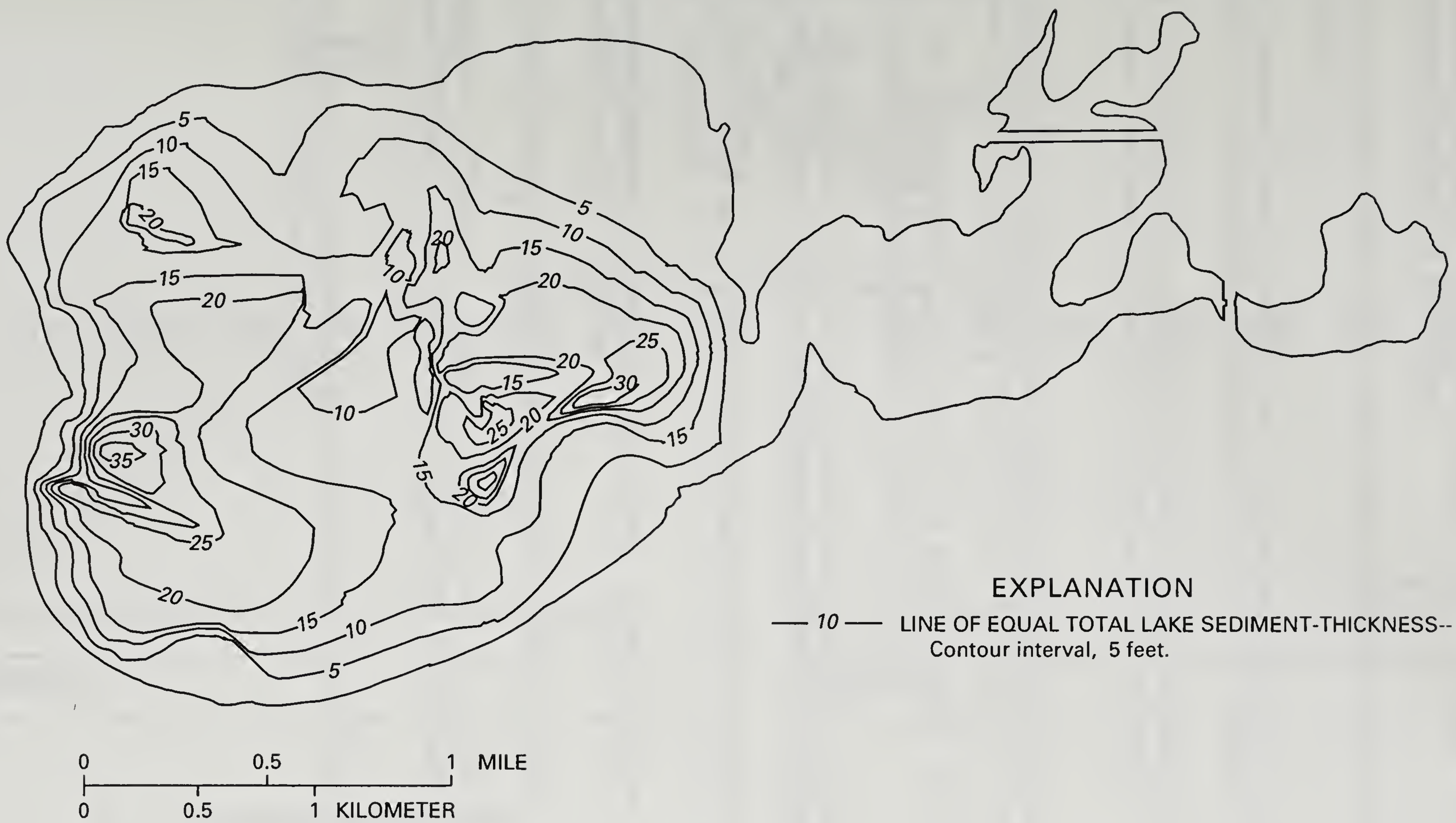

Figure 9.--Total lake sediment (uncompacted plus compacted)-thickness contours for Lake Byron, May 1992.

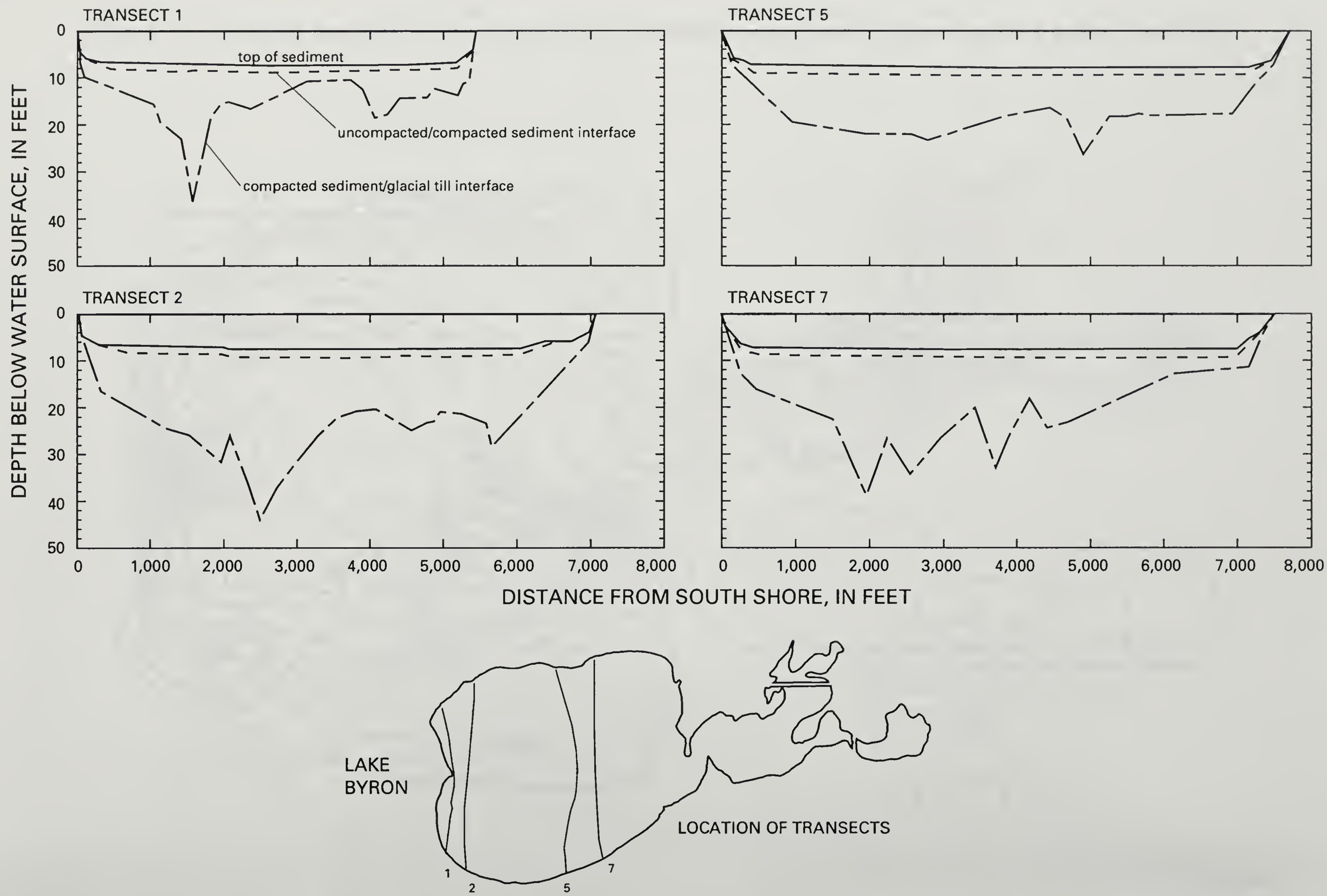

Figure 10.--Interpreted cross-sectional profiles for selected transects for Lake Byron, May 1992.

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